Abstract

Objective: To derive dietary patterns using Principal Components Analysis (PCA) from separate food frequency questionnaires (FFQ) completed by mothers and their teenagers and to assess associations with nutrient intakes and socio-demographic variables.

Design: Two distinct FFQs were completed by 13 year olds and their mothers, with some overlap in the foods covered. A combined dataset was obtained.

Setting: Avon Longitudinal Study of Parents and Children (ALSPAC), Bristol, UK

Subjects: 5334 teenagers with adequate dietary data.

Results: Four patterns were obtained using PCA: a 'Traditional/health-conscious' pattern, a 'Processed' pattern, a 'Snacks/sugared drinks' pattern and finally a 'Vegetarian' pattern. The 'Traditional/health-conscious' pattern was the most nutrient-rich having high positive correlations with many nutrients. The 'Processed' and 'Snacks/sugared drinks' patterns showed little association with important nutrients but were positively associated with energy, fats and sugars. There were clear gender and socio-demographic differences across the patterns. Lower scores were seen on the 'Traditional/health conscious' and 'Vegetarian' patterns in males and in those with younger and less educated mothers. Higher scores were seen on the 'Traditional/health-conscious' and 'Vegetarian' patterns in girls and those with mothers with higher levels of maternal education.

Conclusions: It is important to establish healthy eating patterns by the teenage years. However, this is a time when it is difficult to accurately establish dietary intake from a single source since teenagers consume increasing amounts of foods outside the home. Further dietary pattern studies should focus on teenagers and the source of dietary data collection merits consideration.

Word count: 244

Keywords: ALSPAC, dietary patterns, adolescence, PCA, FFQ

Introduction

Adolescence is an important stage in the life course. It is a period of transition from childhood towards adulthood, not just physically through the mechanics of puberty, but also behaviourally as individuals begin to exert their independence from their parents. Healthy eating patterns established during this time are particularly important as they are likely to track into adulthood [(1)]. Diet is intrinsically linked to a large number of health outcomes and improved dietary intake can help to reduce the risk of many diseases, particularly those related to obesity, such as heart disease, diabetes and cancer [(2, 3)].

Examining overall dietary patterns, as opposed to individual food groups and/or nutrients, has become increasingly popular. It is now established as an appropriate means of investigating the relationships between diet and health outcomes as foods are always eaten in combination. Principal components analysis (PCA), a data reduction technique, uses the correlations between food consumption variables to derive linear combinations of those variables. It is a powerful and commonly-used method of deriving dietary patterns. It has been primarily performed in adults and young children; to our knowledge only five papers have studied dietary patterns specifically in adolescents [(4-8)]. These studies have been performed in Greece [(4)], Spain [(5)], Australia [(6, 7)] and the USA [(8)], with no studies carried out in a UK population.

An added complication in the accurate assessment of dietary intake using food frequency questionnaires (FFQs) in this age group is that parents may not be fully aware of all the foods consumed by their teenagers away from home [(9)] and teenagers may not be able to accurately record the details of all the foods provided for them at home [(10)] therefore a combined approach may be the best option [(11)]. In the Avon Longitudinal Study of Parents and Children (ALSPAC) we have previously always asked parents (usually the mother) to complete the FFQ on behalf of the child. In adolescence, it is important to capture both the parent's and the teenager's reports of what the teenager is consuming therefore, in this study dietary information was collected from both and a combination of the data was used to derive dietary patterns.

We hypothesised that distinct dietary patterns could be extracted from this combined dataset as we have done previously using only parent completed FFQs [(12,13)]. This paper reports on the dietary patterns of these 13 year old children obtained using PCA. To test the validity of the extracted patterns we examine the associations between dietary pattern scores and estimated nutrient intakes; hypothesising that patterns deemed to be more healthy are more nutrient-rich. We also investigate whether there are differences in dietary pattern scores according to socio-demographic factors. We expect that any associations evident will be similar to those we have previously shown during childhood, for example that healthier patterns are consumed by the more socially advantaged. [12, 13].

Methods

ALSPAC is an ongoing population-based study investigating the influence of environment and genetics on development and health [(14)]. ALSPAC recruited 14541 pregnant women resident in the (former) Avon health authority, in South West England, who had expected dates of delivery between 1st April 1991 and 31st December 1992; 13,988 children were alive at 1 year. When the oldest children were approximately 7 years of age, the initial sample was bolstered with eligible cases that failed to join the study originally; the number of additional children that enrolled was 548, therefore 14,536 children in total form the baseline for this study. The primary method of data collection was via self-completion questionnaires, completed by the mother during pregnancy and at various time points afterwards. These were supplemented by questionnaires completed by the children themselves at regular intervals from the age of 7 years. More information is available on the ALSPAC website: http://www.bristol.ac.uk/alspac. Ethical approval for the study was obtained from the ALSPAC Law and Ethics Committee and the Local Research Ethics Committees.

The primary carer, usually the mother figure of the study teenager, was sent a questionnaire when their study child was 157 months (13.1 years) of age. This included a food frequency questionnaire (FFQ) which asked about the frequency of consumption ‘nowadays’ by her teenager of 80 different foods and drinks (see appendix). The mother was asked specifically to respond to the questions only regarding the foods provided by her, including packed lunches but excluding school dinners and other foods consumed outside the home.

Each study teenager was sent an FFQ to complete at the same time (86.0% were completed within 1 month of each other). The teenagers were asked about their consumption of foods ‘nowadays’ that were not included in the mother’s FFQ, that is, foods consumed as part of school dinners, food bought outside school and also additional snacks and drinks. The child’s questionnaire was kept short, only covering foods not in the parental sphere, so as not to place too great a burden on the child. There was some overlap with the mother’s FFQ, for example the teenagers were asked about the foods contained within their packed lunches. Fifty four food groups were included in this FFQ, though some foods were asked about in more than one context (see appendix). For example, teenagers were asked about the chips they consumed as part of school dinners and those bought outside school while the mothers were asked about chips provided at home. All dietary data was collected between 2004 and

2006 and the complete text of all questionnaires can be found on the ALSPAC website. Details of how these variables were treated are given below.

The majority of questions in both FFQs were posed on an ordinal scale, which differed slightly from section to section. All variables were converted to the frequency of consumption per week, as follows: Never or rarely = 0, Once a month or less = 0.25, Once in 2 weeks = 0.5, Once a week = 1, 1-3 times a week = 2, 2-3 times a week = 2.5, 4-5 times a week = 4.5, 4-7 times a week = 5.5, More than once a day = 10 (note that not all options were available for all questions). The frequencies of consumption of bread, fruit, tea and coffee were measured on continuous scales as the number of slices, the number of pieces and the number of cups per day respectively.

The food items from the two FFQs were combined together to create 62 food groups (see appendix). If foods were asked about in both FFQs, or in more than one place, then the following rules were applied to obtain the frequency of consumption of those foods:

- If a food item was included in both FFQs, then the average frequency of consumption was taken from the two sources;
- If two or more food items were combined into a single question in one FFQ but asked about in separate questions in the other, the frequencies were split between each food item to enable combination (for example rice and potatoes were asked about in one question in the teenager's FFQ but were separate items in the mother's FFQ);
- Where food items were asked about in several different sections of the same FFQ, the highest value was taken. For example the teenager's FFQ asked about crisps in a) packed lunches, b) bought outside school and c) total consumption. The frequency of consumption in packed lunches and bought outside school was combined and the highest value between this and the total reported frequency was taken.

A number of socio-demographic and lifestyle variables were considered as potentially being associated with dietary patterns, as we have shown at earlier time points [(13)]. Maternal age and education, and ethnicity were recorded via self-completion questionnaire during pregnancy. The gender of the teenager was noted at birth. Maternal employment status (current employment regardless of full or part time) and whether she lived with a partner were both recorded via self-completion questionnaires when the study children were 11 and

12 years of age respectively. The number of older and younger siblings living with the teenager was recorded when they were 11.5 years of age.

Daily nutrient intakes were estimated from the combined FFQ using the 5th edition of McCance and Widdowson's The Composition of Food [14] and supplements [15, 16]. Additional up to date nutrient information was obtained from the National Diet and Nutrition Survey (NDNS) database and manufacturers' information. Standard portion sizes were assumed based on food records collected at 13.5-years [11] these were also used to inform the selection of foods to include in each food group for the nutrient calculations.

Statistical Methods

In order to compare the teenager's report of their frequency of consumption compared to their mother's report, Pearson's correlations were calculated for selected foods (those where teenager report would theoretically have been included in the maternal report and therefore some level of agreement would be expected).

The 62 food frequency variables were entered into a PCA with varimax rotation [17, 18]. Our methods have been described in detail elsewhere [12, 13]. Briefly, PCA exploits the structure in the correlation between variables to create factors that explain as much variation in the data as possible. The components that are derived are linear combinations of the food frequency variables, and each subject has a resulting score for each component. The factor loadings, which are the correlations between the components and each variable, indicate which foods are important for each component and are used to help describe the resulting dietary patterns. Loadings above 0.30 are highlighted as being particular important in assisting in labelling the patterns. The choice of the number of components to retain was based on the scree plot [19] together with the interpretability of the resulting components. Teenagers who had more than 10 missing values in either FFQ were excluded from the PCA (n=785), those with 10 or fewer had missing values put to zero, thereby assuming that they did not consume those foods.

Linear regression was used to examine the associations between the component scores and the socio-demographic variables, the association for each variable being adjusted for all others in order to determine independent relationships. The component scores were standardized by dividing by their standard deviations in order to facilitate comparisons between associations with different dietary patterns. Spearman's correlation coefficients were calculated to measure the associations between the dietary patterns scores and the respective nutrient intakes. Additionally, partial correlation coefficients were calculated, adjusting for energy intake. The proportion of variance explained by the dietary pattern scores were obtained for both absolute and energy-adjusted nutrient intakes by summing the squares of the correlations with each dietary pattern for each nutrient. Adjusted parameter estimates and 95% confidence intervals (CI) are presented throughout. All analyses were performed using Stata v.11.1.

Results

A total of 7152 mothers and 7119 teenagers returned their respective questionnaires at 13.1 years. Both sources of data were available for 6203 (43% of baseline) teenagers and of these 5418 (87.3%) had sufficient dietary data available for analysis. Table 1 presents the correlations for foods where both the teenager and the mother reported intakes. The correlations ranged from 0.183 for meat pies/pasties to 0.528 for fruit, though all were p<0.001.

Four principal components were retained, explaining 20.8% of the variance in food frequencies of the sample. The factor loadings for each dietary pattern are shown in Table 2. The first component had high positive loadings for meat, fish, eggs, cheese, rice, pasta, potatoes, vegetables, salad, fruit, pulses, brown and wholemeal bread dairy-based desserts, puddings, salad dressings, and water. It had high negative loadings for white bread and coated poultry products. This component was named the 'Traditional/health-conscious' pattern as it appeared to overlap with the 'Health conscious' and 'Traditional' patterns that we have previously described at younger ages (12, 13). The second component had high loadings for processed meat, coated poultry and fish products, chips, roast potatoes, pizza, tinned pasta and baked beans, ketchup, sandwiches, cakes and buns, puddings, and dairy-based desserts. There was a large negative loading on brown and wholemeal bread. This pattern was named 'Processed', in line with previous findings (12, 13). The next component had high loadings for crisps, biscuits, chocolate, sweets, squash and fizzy drinks. We chose to name this component the 'Snacks/sugared drinks' pattern. The final component had high positive loadings for vegetarian-style foods (such as meat substitutes, nuts and pulses) and high negative loadings for meats and was therefore labelled the 'Vegetarian' pattern.

The associations between the dietary pattern scores and the socio-demographic variables are shown in Table 3 for the 3951 teenagers with complete data. Scores were higher on the 'Traditional/health-conscious' pattern for females, as levels of maternal education increased (all p<0.001), and if mothers were not in employment. For the 'Processed' pattern scores were higher in males, if mothers were younger or less educated, and when 2 or more older or younger siblings were present (the majority p<0.001). Scores on the 'Snacks/sugared drinks' pattern were higher in males, when mothers were younger or less educated (all p<0.001), and in the presences of siblings, both younger and older (p=0.006 and p=0.011 respectively). Teenagers with working mothers also scored higher on this pattern (p=0.002).

Finally, the ‘Vegetarian’ pattern was strongly associated with being female or having a degree-educated mother (both p< 0.001). There was also some evidence to suggest that ethnicity was associated with the ‘Snacks/sugared drinks’ and ‘Vegetarian’ patterns with white children scoring higher on the ‘Snacks/sugared drinks’ pattern and non-white children scoring higher on the ‘Vegetarian’ factor pattern (both p<0.05).

Table 4 shows the absolute and energy adjusted correlations between the dietary pattern scores and estimated nutrient intakes. Strong positive correlations (*r* >0.5) were evident between the ‘Traditional/health conscious’ pattern and the absolute intake of many of the nutrients including protein, fibre, potassium, magnesium, zinc, vitamin C, folate and carotene. These correlations were robust to adjustment for energy, as the coefficients barely changed showing this to be a nutrient-rich pattern. The ‘Processed’ pattern was positively correlated with absolute intakes of energy, fat, carbohydrates and sodium intakes. After adjustment for energy intake, the highest correlations were seen between this pattern and polyunsaturated fat and sodium (*r*=0.408 and 0.378 respectively). Positive correlations (*r* >0.5) were seen between the ‘Snacks/sugared drinks’ pattern and absolute intakes of energy, fat, carbohydrates and sugar. However, after energy adjustment negative associations immerged with protein, fibre, potassium iron, zinc and niacin (*r* < -0.3) and a positive association with sugar (*r* = 0.336). Finally, the ‘Vegetarian’ pattern did not show any strong associations with any of the absolute nutrient intakes. After energy adjustment, the largest correlations were seen with protein (*r* = -0.445), zinc (*r* = -0.336) and niacin (*r* = -0.476). The proportion of the variation of absolute intakes was explained well by the dietary patterns for many nutrients, with over 50% explained for energy, protein, fibre, potassium, magnesium, zinc and niacin after energy adjustment.

Discussion

In a contemporary cohort of 13-year-olds we have obtained four underlying dietary patterns using PCA: 'Traditional/Health-conscious', 'Processed', 'Snacks/sugared drinks' and 'Vegetarian'. Three of these patterns are similar to those we have previously reported in this cohort [20] however, this time a new pattern has emerged: the 'Snacks/sugared drinks' pattern. It is not clear whether this is due to the difference in input variables in this analysis compared to those used previously or whether this is due to a genuine change in patterns of intake over time. We did not rely on parental report only, as we had in previous work, but questioned these older children directly about the foods they consumed and purchased outside the home via a FFQ designed for that purpose.

When we restricted the analysis to the data provided by the mothers only we obtained 3 patterns: 'Health-conscious', 'Processed' and 'Vegetarian'. These are much more in line with the patterns we obtained at 9 years of age [20]. However, this restriction ignores foods consumed as school dinners or purchased outside the home. For many teenagers these foods contribute a substantial amount to their total intake and it is important that they are included. Furthermore, the mother's FFQ did not include questions on the consumption of squashes/cordials and carbonated drinks and, crisps, biscuits, chocolate and sweets. These foods can be considered to be non-essential or non-core foods [19] as they provide very few nutrients yet are high in energy and extremely palatable. All these foods loaded highly on the 'Snacks/sugared drinks' pattern. It was important therefore that we did not rely on the mother's data alone.

There were reasonable levels of correlation between maternal and subject report of those foods that were asked of both mother and teenager (all $p<0.0001$). However, the correlations were lowest for those items that could be eaten more readily outside the home (meat pies/pasties, lunchbox snacks and cakes/buns). The highest correlations were seen with the foods that are considered to be healthier. The low level of overlap between the two FFQs did not allow us to make a more formal comparison between parental and subject report. Other studies have shown relatively low levels of agreement in younger children [21-23]. A recent Swedish study reported that 10-12 year old children generally agreed with their parent's report of their meal patterns but differences were evident regarding the consumption of sweets and chocolate, with the children reporting less frequent consumption [25]. Further research is required in adolescents to determine whether they can accurately report their dietary intake. It is important to capture all sources of food at this age. The mother is still the primary provider for her 13-year-old child but the child is likely to purchase foods outside of the home and consume foods at school that the mother is not aware of. For this reason we feel our approach of using both parent and child completed FFQ is justified.

Five other studies to date have examined dietary patterns in adolescents [(4-8)]. Generally, the patterns obtained in these studies differ to those we report here. For some this may be due to cultural differences, such as those from Greece [(4)] and Spain [(5)], but it may also be due to the fact that adolescents were included in a wider age group: 12-17 year olds [(4)], 2-24 year olds [(5)] and 12-18 year olds [(7)]. It is quite possible that dietary patterns will change over these periods and this makes comparisons with a much narrower age range difficult. An American study of 13-year-olds identified four patterns named 'vegetable', 'fruit', 'sweet/salty snack food' and 'starchy food' [(8)] with a few similarities to those reported here. The most comparable patterns were obtained from 14-year-olds taking part in the Australian Raine Study [(6)]. Two patterns were obtained: 'Western' and 'Healthy' and the foods loading highly on these patterns were very similar to those associated with our 'Processed' and 'Traditional/Health-conscious' patterns respectively. In these studies the adolescents provided the information on their dietary intake, with the exception of the Raine Study which sent the questionnaire to the main carer with instructions to complete the dietary sections in association with the study adolescent [(6)].

Clear gender and socio-demographic differences in the dietary patterns in ALSPAC have been reported previously in the ALSPAC children [(12, 13)] and similar differences are evident at 13 years of age. In particular, higher scores on the less healthy patterns ('Processed' and 'Snacks/sugared drinks') were seen in males and those with younger and less educated mothers. Conversely, higher scores on the healthier patterns ('Traditional/health-conscious' and 'Vegetarian') were seen in girls and those with mothers with higher levels of maternal education. Of the five studies published to date exploring dietary patterns in adolescence, four examined possible associations with socio-demographic variables [(4,5,7,8)]. Despite the differences in the patterns themselves and the variables that were examined, similar patterns of association were observed. In particular, the Spanish study [(5)] reported an inverse association between their 'snacky' pattern (associated with sweets, salted snacks, cakes, biscuits and soft drinks) and maternal education level but a positive association was seen with the 'healthy' pattern. Girls were also more likely to adhere to the 'healthy' pattern. Similarly, Cutler *et al* in their American population of 14 year olds reported positive associations between socioeconomic status (a composite score based primarily on parental educatioal level) and the 'vegetable' and 'fruit' patterns but negative associations with the 'sweet/salty snack food' and 'starchy food'. The Australian study of 12-18 year olds [(6)] reported that males were more likely to adhere to the 'high fat and sugar' pattern. However, no associations were evident with household income, the only socio-demographic factor examined.

Few other studies have examined the association between nutrient intakes and dietary patterns in adolescence. However, the associations we have demonstrated between the dietary pattern scores and nutrient intakes are virtually identical to those that we saw in the mothers of these children during pregnancy [(26)]. We have shown that the 'Traditional/health-conscious' pattern is nutrient-rich with high positive correlations with many nutrients. The two patterns deemed to be less healthy: 'Processed' and 'Snacks/sugared drinks' showed little association with important nutrients but were positively associated with energy, fat and sugars. One other UK study has examined the associations between dietary patterns and nutrient intakes in slightly younger children (11-year-olds) [(27)]. All these studies demonstrated positive nutrient profiles with the more 'healthy' dietary patterns and less desirable nutrient profiles with the more 'unhealthy' dietary patterns. The findings in that study were also similar to those reported here. Taken together these results add to the evidence that dietary patterns are a useful way of summarising diet, giving credibility to their representativeness of overall diet.

There are limitations to this study which warrant discussion. The use of two FFQ, one to each of the parent and child, covering slightly different foods and eating occasions may have led to some bias however we felt that only using one source would have been likely to lead to different biases [(6)]. We were further constrained by the requirement to keep the questionnaire to the teenager as short as possible. Out of necessity, a number of assumptions were made when combining the two sets of dietary data, however, it is unlikely that recall bias is a major problem since we asked only about 'current' consumption. Missing data is an issue in the adjusted analyses however our sensitivity analysis showed that this did not influence the patterns found. We carried out a sensitivity analyses to explore the dietary patterns obtained from the subsample with complete socio-demographic and mode of eating data. The factor loadings obtained from the PCA were virtually identical to the original solution (data not shown). It could be argued that residual confounding is a problem in the adjusted analyses, however, these analyses were not designed to identify independent associations.

In conclusion, we have identified distinct dietary patterns evident at 13 years of age, using combined parental and child reported data, which are clearly socially patterned and associated with nutrient intakes in the way we would expect. As hypothesised we have shown that teenagers who have eating difficulties, who consume snacks rather than whole meals and who consume packed lunches are less likely to follow a 'healthy' diet. These patterns will form the basis for future research into the longitudinal nature of dietary patterns from childhood into adolescence and their subsequent associations with health outcomes.

References

1. Mikkila V, Rasanen L, Raitakari OT *et al*. (2005). Consistent dietary patterns identified from childhood to adulthood: The Cardiovascular Risk in Young Finns Study. *Br J Nutr* **93**, 923-931.
2. World Health Organization/Food and Agriculture Organization (2003). Diet, nutrition and the prevention of chronic diseases - report of a Joint WHO/FAO Expert Consultation. *World Health Organization,* Geneva.
3. World Cancer Research Fund/American Institute for Cancer Research (2007). Food, nutrition, physical activity, and the prevention of cancer: a global perspective. *AICR*, Washington DC.
4. Kourlaba G, Panagiotakos DB, Mihas K *et al*. (2008). Dietary patterns in relation to socio-economic and lifestyle characteristics among Greek Adolescents: a multivariate analysis. *Pub Health Nutr* **12**, 1366-1372.
5. Aranceta J, Perez-Rodrigo C, Ribas L *et al*. (2003). Socio-demographic and lifestyle determinants of food patterns in Spanish children and adolescents: the enKid study. *Eur J Clin Nutr* **57** (suppl 1), S40-S44.
6. Ambrosini GL, O'Sullivan TA, de Klerk NH *et al*. (2011). Relative validity of adolescent dietary patterns: a comparison of a FFQ and 3 d food record. *Br J Nutr* **105**, 625-633.
7. McNaughton SA, Ball K, Mishra GD *et al*. (2008). Dietary patterns of adolescents and risk of obesity and hypertension. *J Nutr* **138**, 364-370.
8. Cutler GJ, Flood A, Hannan P *et al*. (2011). Multiple socio-demographic and socioenvironmental characteristics are correlated with major patterns of dietary intake in adolescents. *J Am Diet Assoc* **111**, 230-240.
9. Livingstone MBE, Robson PJ, Wallace JMW (2004). Issues in dietary intake assessment of children and adolescents. *Br J Nutr* **92** (Suppl 2), S213-S222.
10. Collins CE, Watson J, Burrows T (2010). Measuring dietary intake in children and adolescents in the context of overweight and obesity. *Int J Obesity* **34**, 1103-1105.
11. Ambrosini GL, Emmett PM, Northstone K, Howe LD, Tilling K, Jebb SA (2012). Identification of a dietary pattern prospectively associated with increased adiposity during childhood and adolescence. *Int J Obes* doi:10.1038/ijo.2012.127.

12. North K, Emmett P and the ALSPAC Study Team (2000). Multivariate analysis of diet among three-year old children and associations with socio-demographic characteristics. *Eur J Clin Nutr* **54**, 73-80.
13. Northstone K, Emmett P and the ALSPAC Study Team (2005). Multivariate analysis of diet in children at four and seven years of age and associations with socio-demographic characteristics. *Eur J Clin Nutr* **59**, 751-760.
14. Boyd A, Golding J, Macleod J, Lawlor DA, Fraser A, Henderson J, Molloy L, Ness A, Ring S, Davey Smith G (2012). Cohort Profile: The 'Children of the 90s'—the index offspring of the Avon Longitudinal Study of Parents and Children. *Int J Epidemiol*. Doi: 10.1093/ije/dys064.
15. Holland B, Welch AA, Unwin ID, Buss DH, Paul AA, Southgate DAT. McCance & Widdowson's The composition of foods, 5th edition. 5th ed. Cambridge: The Royal Society of Chemistry, 1991.
16. Holland B, Unwin ID, Buss DH. Fruit and nuts. First supplement to 5th edition of McCance & Widdowson's The Composition of Foods. Cambridge: The Royal Society of Chemistry, 1992.
17. Chan W, Brown J, Lee SM, Buss DH. Meat, Poultry and Game. Fifth supplement to 5th edition of McCance and Widdowson's The Composition of Foods. Cambridge: The Royal Society of Chemistry, 1995.
18. Gorsuch RL (1974). Factor Analyses. *WB Saunders*: Philadelphia, PA.
19. Kline P (1994). An Easy Guide to Factor Analysis. *Routledge*: London.
20. Cattell RB (1966). The screen test for the number of factors. *Multivariate Behav Res* **1**, 245–276.
21. Northstone K, Emmett PM (2008). Are dietary patterns stable throughout early and mid-childhood? A birth cohort study. *Br J Nutr* **100**, 1069-76.
22. Koh GA, Scott JA, Oddy WH, Graham KI, Binns CW. Exposure to non-core foods and beverages in the first year of life: Results from a cohort study. Nutr Diet 2010;67(3):137-42. doi: 10.1111/j.1747-0080.2010.01445.x.
23. Tak NI, te Velde SJ, de Vries JHM *et al*. (2006). Parent and child reports of fruit and vegetable intakes and related family environmental factors show low levels of agreement. *J Hum Nutr Diet* **19**, 275-285.
24. Reinaerts E, de Nooijer J, de Vries NK (2007). Parental versus child reporting of fruit and vegetable consumption. *Int J Behav Nutr Phys Act* **4**, 33.

25. Persson Osowski C, Fjellstrom C, Olsson U *et al*. (2011). Agreement between child and parent reports of 10- to 12-year-old children's meal pattern and intake of snack foods. early online publication DOI: 10.1111/j.1365-277X.2011.01169.x

26. Northstone K, Emmett PM, Rogers I (2008). Dietary patterns in pregnancy and associations with nutrient intakes. *Br J Nutr* **99**, 406-415.

27. Patel S, Murray CS, Simpson A *et al.* (2011) Dietary patterns of 11-year-old children and associations with nutrient intakes. *J Hum Nutr Diet* **24**, 399-400.

Table 1: Correlations between maternal and teenage reports of the frequency of consumption of selected foods

Food group	Correlation
Meat pies/pasties	0.183
Salad	0.352
Lunchbox snacks	0.212
Yoghurts/fromage frais	0.309
Cakes/buns	0.224
Flavoured milk drinks	0.403
Fruit juice	0.510
Water	0.486
Fruit	0.528

All $p<0.001$

Table 2: Factor loadings for the four dietary patterns identified by PCA using two combined FFQs assessing diet in 5418 13 year olds. Factor loadings greater than |0.30| are shown in bold.

Factor (variance explained) **Food item**	**Traditional/ Health-conscious (6.61%)**	**Processed (6.15%)**	**Snacks/ Sugared drinks (4.25%)**	**Vegetarian (3.79%)**
Meat dishes	**0.304**	0.176	-0.094	**-0.642**
Cold meats	0.012	-0.006	0.153	**-0.414**
Poultry	0.268	-0.031	0.037	**-0.606**
Meat sausages/burgers	-0.119	**0.554**	-0.038	-0.188
Meat pies/pasties	0.028	**0.506**	0.006	-0.095
Offal	0.088	0.010	0.023	-0.087
Fish	**0.431**	-0.002	-0.044	-0.077
Chicken/turkey in crispy coating	-0.249	**0.419**	-0.004	-0.122
White fish in breadcrumbs/batter	0.070	**0.338**	-0.080	-0.109
Eggs	**0.332**	0.226	-0.081	0.140
Cheese	0.254	0.046	0.083	0.245
Rice	**0.488**	0.124	-0.120	-0.103
Pasta	**0.403**	0.141	-0.061	0.058
Pizza	0.016	**0.577**	-0.012	0.185
Baked beans/tinned pasta	0.015	**0.535**	-0.075	0.022
Fried food	0.054	**0.363**	-0.115	0.034
Raw fruit	**0.353**	-0.141	-0.053	0.082
Tinned fruit	0.115	0.148	0.037	0.038
Salad	**0.583**	-0.125	-0.031	0.078
Peas	**0.430**	0.077	0.012	-0.117
Sweetcorn	**0.466**	0.123	-0.020	-0.038
Green vegetables	**0.635**	-0.164	0.038	-0.119
Root vegetables	**0.641**	-0.142	0.106	-0.152
Meat substitutes	0.163	0.052	0.015	**0.667**
Vegetarian pies/pasties	0.210	0.255	-0.063	**0.475**
Nuts	0.252	-0.028	0.022	**0.310**
Pulses	**0.350**	-0.071	-0.045	**0.375**
Potatoes	**0.433**	0.098	0.021	-0.203
Roast potatoes	0.115	**0.464**	-0.033	-0.207
Chips	-0.193	**0.674**	0.013	0.047
Crisps	-0.097	0.040	**0.672**	0.025
Biscuits	0.069	-0.082	**0.779**	-0.014
Crispbreads	0.168	0.030	0.031	0.186
Chocolate	0.009	-0.041	**0.817**	0.008
Sweets	-0.013	0.170	**0.541**	0.007
White bread (slices)	-0.239	0.258	0.003	0.010
Other bread (slices)	**0.290**	**-0.311**	0.124	0.077
Butter / margarine	0.034	-0.015	0.181	0.058

Factor (variance explained) **Food item**	**Traditional/ Health-conscious (6.61%)**	**Processed (6.15%)**	**Snacks/ Sugared drinks (4.25%)**	**Vegetarian (3.79%)**
Non-homemade sandwiches	0.051	0.288	-0.063	0.075
Lunchbox snacks	-0.083	0.235	0.088	0.064
Yoghurt/fromage frais	0.278	0.019	0.158	0.030
Puddings	**0.333**	**0.366**	-0.104	-0.036
Milk puddings/custard/mousse	**0.258**	**0.373**	0.040	0.013
Ice cream	0.065	**0.260**	0.146	0.071
Ice lollies	-0.003	**0.316**	0.117	0.094
Cakes/buns	0.193	**0.305**	0.146	0.021
Ketchup/brown sauce	-0.028	**0.407**	0.012	0.065
Mayonnaise/salad cream/dressing	0.273	0.101	0.052	0.063
Oat-based cereal	0.228	-0.026	-0.031	0.019
Bran-based-cereal	0.205	-0.107	0.080	-0.025
Other cereal	-0.060	0.083	0.093	-0.006
Cereal bars	-0.002	0.133	0.033	0.128
Full fat milk	-0.010	0.110	0.017	0.015
Other milk	0.122	-0.061	0.069	-0.004
Flavoured milk drinks	0.136	0.129	0.247	0.041
Fruit juice	0.247	-0.028	0.006	0.093
Squash/cordial	-0.024	-0.041	**0.347**	-0.071
Water	0.292	-0.120	-0.033	0.061
Fizzy drinks	-0.106	0.265	**0.335**	-0.028
Tea/coffee	0.074	0.044	0.129	-0.023
Herbal tea	0.147	-0.028	-0.054	0.072
Alcohol	0.107	0.044	0.019	0.069

Table 3: Adjusted[a] associations (parameter estimates and 95% confidence intervals) between socio-demographic characteristics and standardized dietary pattern scores in 3951 13 year olds.

Characteristic	n	Traditional /health-conscious	Processed	Snacks/sugared drinks	Vegetarian
Gender					
Male	1916	Ref	Ref	Ref	Ref
Female	2035	-0.148 (0.090, 0.207)	-0.231 (-0.288, -0.173)	-0.140 (-0.200, -0.081)	-0.224 (0.164, 0.285)
		p < 0.001	p < 0.001	p < 0.001	p < 0.001
Ethnicity of child					
White	3830	Ref	Ref	Ref	Ref
Non-white	121	-0.049 (-0.121, 0.220)	-0.045 (-0.212, 0.123)	-0.174 (-0.346, -0.001)	-0.194 (0.019, 0.370)
		p = 0.571	p = 0.601	p = 0.048	p = 0.030
Maternal age					
31 plus	1564	Ref	Ref	Ref	Ref
26 – 30	1745	-0.070 (-0.138, -0.002)	-0.080 (0.013, 0.146)	-0.144 (0.075, 0.212)	-0.072 (-0.142, -0.002)
21 – 25	568	-0.077 (-0.176, 0.022)	-0.148 (0.051, 0.245)	-0.273 (0.173, 0.373)	-0.136 (-0.238, -0.034)
up to 20	74	-0.060 (-0.288, 0.168)	-0.434 (0.210, 0.658)	-0.261 (0.030, 0.492)	-0.044 (-0.279, 0.191)
		p = 0.208	p < 0.001	p < 0.001	p = 0.052
Maternal education[b]					
CSE	397	Ref	Ref	Ref	Ref
Vocational	266	-0.220 (0.074, 0.366)	-0.182 (-0.325, -0.038)	-0.105 (-0.253, 0.043)	-0.096 (-0.246, 0.054)
O level	1348	-0.446 (0.340, 0.552)	-0.304 (-0.408, -0.200)	-0.130 (-0.237, -0.022)	-0.023 (-0.132, 0.086)
A level	1139	-0.714 (0.605, 0.824)	-0.470 (-0.577, -0.362)	-0.415 (-0.525, -0.304)	-0.079 (-0.034, 0.191)
Degree	801	-0.908 (0.791, 1.026)	-0.649 (-0.764, -0.533)	-0.628 (-0.747, -0.509)	-0.262 (0.141, 0.383)
		p < 0.001	p < 0.001	p < 0.001	p < 0.001
Mother has a partner					
Yes	3776	Ref	Ref	Ref	Ref
No	175	-0.103 (-0.245, 0.041)	-0.020 (-0.121, 0.161)	-0.138 (-0.283, 0.006)	-0.081 (-0.228, 0.066)
		p = 0.161	p = 0.780	p = 0.061	p = 0.282

Characteristic	n	Traditional /health-conscious	Processed	Snacks/sugared drinks	Vegetarian
Mother in employment					
Yes	3231	Ref	Ref	Ref	Ref
No	720	-0.126 (0.048, 0.204)	-0.014 (-0.063, 0.091)	-0.129 (-0.208, -0.050)	-0.010 (-0.070, 0.091)
		p = 0.002	p = 0.716	p = 0.001	p = 0.804
Older siblings					
0	2044	Ref	Ref	Ref	Ref
1	1426	-0.002 (-0.074, 0.069)	-0.038 (-0.032, 0.109)	-0.073 (0.001, 0.146)	-0.028 (-0.046, 0.102)
2 or more	481	-0.019 (-0.120, 0.083)	-0.134 (0.034, 0.234)	-0.150 (0.047, 0.252)	-0.051 (-0.053, 0.156)
		p = 0.935	p = 0.031	p = 0.011	p = 0.586
Younger siblings					
0	1853	Ref	Ref	Ref	Ref
1	1561	-0.027 (-0.046, 0.100)	-0.011 (-0.061, 0.082)	-0.117 (0.043, 0.191)	-0.021 (-0.054, 0.097)
2 or more	537	-0.002 (-0.106, 0.102)	-0.181 (0.079, 0.283)	-0.042 (-0.063, 0.147)	-0.079 (-0.028, 0.186)
		p = 0.700	p = 0.001	p = 0.006	p = 0.343

[a] adjusted for all other variables in the table

[b] CSEs equivalent to full time education up to age 16 years but at a lower level of achievement to O levels; O level equivalent to full time education up to age 16 years; A level equivalent to full time education up to age 18 years.

Table 4: Correlation coefficients between dietary pattern scores and daily absolute nutrient intakes and partial correlation coefficients between dietary pattern scores and daily nutrient intakes adjusting for energy intake in 3902 13 year olds

Nutrient	**'Traditional/ Health-conscious'**		**'Processed'**		**'Snacks/sugared drinks'**		**'Vegetarian**		**% var explained**	
	Absolute	**Adjusted**	**Absolute**	**Adjusted**	**Absolute**	**Adjusted**	**Absolute**	**Adjusted**	**Absolute**	**Adjusted**
Energy	0.208		0.649		0.584		-0.092		81.4	
Total fat	0.151	-0.209	0.662	0.185	0.579	0.068	-0.067	0.076	80.1	8.8
Protein	0.461	0.510	0.577	0.154	0.263	-0.410	-0.349	-0.453	73.6	65.7
Monounsaturated fat	0.118	-0.280	0.680	0.270	0.579	0.079	-0.129	-0.110	82.6	17.0
Polyunsaturated fat	0.248	0.140	0.695	0.409	0.346	-0.240	0.006*	0.127	66.4	26.1
Saturated fat	0.088	-0.300	0.552	-0.179	0.618	0.256	-0.053	0.083	69.7	19.4
Carbohydrates	0.159	-0.118	0.578	-0.168	0.613	0.240	-0.048	0.131	73.7	11.7
Sugar	0.101	-0.140	0.397	-0.383	0.638	0.334	-0.018*	0.104	57.5	28.9
Fibre	0.616	0.644	0.299	-0.166	0.178	-0.315	0.062	0.142	50.4	56.2
Potassium	0.538	0.626	0.509	0.032	0.293	-0.345	-0.159	-0.144	66.0	53.3
Sodium	0.233	0.101	0.700	0.379	0.380	-0.269	-0.098	-0.026*	69.8	22.1
Calcium	0.313	0.253	0.477	-0.087	0.410	-0.119	0.080	0.252	49.9	15.0
Magnesium	0.541	0.667	0.387	-0.314	0.337	-0.312	0.010*	0.139	55.6	66.0
Iron	0.462	0.497	0.381	-0.262	0.307	-0.302	-0.018*	0.080	45.3	41.3
Zinc	0.539	0.609	0.456	-0.094	0.252	-0.377	-0.290	-0.345	64.6	64.1
Vitamin C	0.541	0.517	0.013	-0.177	-0.054	-0.212	0.046	0.063	29.8	34.7
Iodine	0.363	0.326	0.436	-0.179	0.429	-0.071	-0.052	-0.035*	50.9	14.5
Selenium	0.425	0.391	0.294	-0.252	0.198	-0.319	-0.086	-0.035	31.4	31.9

Nutrient	'Traditional/ Health-conscious'		'Processed'		'Snacks/sugared drinks'		'Vegetarian		% var explained	
	Absolute	Adjusted	Absolute	Adjusted	Absolute	Adjusted	Absolute	Adjusted	Absolute	Adjusted
Folate	0.571	0.580	0.330	-0.106	0.176	-0.297	-0.007*	0.055	46.6	43.9
Carotene	0.641	0.622	0.000*	-0.158	0.018*	-0.129	-0.135	-0.138	42.9	44.7
Retinol	0.309	0.241	0.314	0.003*	0.153	-0.201	0.031*	0.084	21.8	10.6
Vitamin E	0.219	0.096	0.557	0.122	0.412	-0.076	0.021	0.153	52.8	25.3
Thiamin	0.472	0.464	0.417	-0.052	0.233	-0.288	0.002*	0.098	45.1	31.1
Niacin	0.454	0.464	0.510	0.099	0.220	-0.368	-0.400	-0.484	67.5	59.5
Riboflavin	0.356	0.306	0.256	-0.236	0.305	-0.077	0.132	0.234	30.2	21.0
Vitamin B6	0.433	0.407	0.513	0.128	0.227	-0.285	-0.328	-0.362	60.9	39.4
Vitamin B12	0.469	0.431	0.408	0.042*	0.161	-0.259	-0.250	-0.240	47.5	31.2
Vitamin D	0.386	0.341	0.265	-0.020	0.062	-0.268	-0.096	-0.067	23.2	19.3
n-3 fatty acids (from fish)	0.346	0.334	-0.052	-0.102	-0.127	-0.186	-0.001*	-0.002*	13.9	15.7
DHA (from fish)	0.328	0.316	-0.054*	-0.101	-0.127	-0.184	-0.001*	0.002*	12.7	14.4
EPA (from fish)	0.320	0.311	-0.072	-0.113	-0.130	-0.178	0.015	0.012	12.5	14.1

All P < 0.001 except those marked *

Appendix: Food groups included in the analysis, indicating the source of each question. The numbers show how many questions contributed to each food group from each questionnaire

Food groups	Mother's FFQ	Teenager's FFQ			
		Packed lunch	School dinner	Bought food	All food
Meat dishes	1		2		
Cold meats	1	1			
Poultry	1				
Meat sausages/burgers	1		1	1	
Meat pies/pasties	1	1	1	1	
Offal	1				
Fish	4		1		
Chicken/turkey in crispy coating	1				
White fish in breadcrumbs/batter	1		1		
Eggs	1		1		
Cheese	1	1			
Rice	1		1		
Pasta	1		1		
Pizza	1		1	1	
Baked beans/tinned pasta	2		1		
Fried food	1				
Raw fruit	1	1	1	1	1
Tinned fruit	1				
Salad	2	1	1		
Peas	1		1		
Sweetcorn	1		1		
Green vegetables	1		1		
Root vegetables	2		1		
Meat substitutes	2				
Vegetarian pies/pasties	1		1		
Nuts	2				
Pulses	1				
Potatoes	1		1		
Roast potatoes	1		1		
Chips	2		1	1	
Crisps		1		1	1
Biscuits					2
Crispbreads	1				
Chocolate/sweets			1	1	2
White bread	1				
Other bread	1				
Butter / margarine	1				
Non-homemade sandwiches		1	1	1	
Lunchbox snacks	1	1			
Yoghurt/fromage frais	1		1		
Puddings	1		1		

Food groups	Mother's FFQ	Teenager's FFQ			
		Packed lunch	School dinner	Bought food	All food
Milk puddings/custard/mousse	2		1		
Ice cream	1				
Ice lollies	1	1			
Cakes/buns	1		1		
Ketchup/brown sauce	1				
Mayonnaise/salad cream/dressing	1				
Oat-based cereal	1				
Bran-based-cereal	1				
Other cereal	1				
Cereal bars	1				
Full fat milk to drink	1				
Other milk to drink	1				
Flavoured milk drinks	1				1
Fruit juice	1				1
Squash					1
Water	2				1
Fizzy drinks					2
Tea/coffee	2				
Herbal tea	1				
Alcohol	4				